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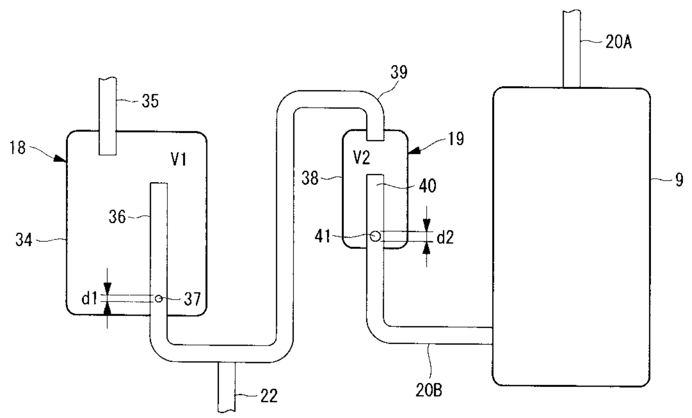
(54) **Refrigerant circuit system**

(57) It is an object of the present invention to provide a refrigerant circuit system in which the volume of a plurality of accumulators provided in series and the size of an oil return hole are appropriately set so as to achieve both the prevention of liquid backflow and the prevention of oil discharge from a compressor caused by deteriorated oil return. The refrigerant circuit system includes: a compressor 9 having a refrigerant suction pipe 20B; a first accumulator 18; and a second accumulator 19, the first accumulator 18 and the second accumulator 19 being provided in series inside the refrigerant suction pipe 20B of the compressor 9 along a refrigerant circulation direction, wherein the first accumulator 18 and the second accumulator 19 are adapted to satisfy V1 > V2 where V1 is a volume of the first accumulator 18 and V2 is a volume of the second accumulator 19, and wherein the first accumulator 18 and the second accumulator 19 are also adapted to satisfy A1 < A2 where A1 is an opening area of a first oil return hole 37 provided in a refrigerant exit pipe 36 of the first accumulator 18 and A2 is an opening area of a second oil return hole 41 provided in a refrigerant exit pipe 40 of the second accumulator 19.

FIG. 2



Description

{Technical Field}

[0001] The present invention relates to a refrigerant circuit system applicable to chillers, air conditioners, heat pumps, and the like.

{Background Art}

[0002] Some refrigerant circuit systems, which are applicable to chillers, air conditioners, heat pumps and the like, are structured to have a plurality of accumulators provided inside a refrigerant suction pipe extending to a compressor, the accumulators being placed in series along a circulation direction of a refrigerant so that liquid backflow to the compressor is more effectively prevented (see, for example, Japanese Unexamined Patent Application, Publication No. 2009-236397 and Japanese Unexamined Patent Application, Publication No. 2011-47545).

[0003] When a plurality of the accumulators are placed in series in such a manner, the accumulator placed upstream side in the refrigerant circulation direction is often made to have a larger volume than the accumulator placed downstream side, and the downstream-side small accumulator with a reduced volume is mounted onto an outer circumference of a housing of the compressor so as to be structured integrally with the compressor.

{Summary of Invention}

{Technical Problem}

[0004] As described above, a plurality of the accumulators placed in series can prevent liquid backflow to the compressor more effectively. However, if an oil return hole provided in a refrigerant exit pipe of each accumulator was not appropriately sized, liquid backflow to the compressor could not appropriately be blocked in some cases, and oil discharge from the compressor occurred due to deteriorated oil return to the compressor in other cases.

[0005] Particularly when an oil separator was provided inside a refrigerant discharge pipe of the compressor to form such a cycle that the oil separated in the oil separator was returned to the refrigerant suction pipe of the compressor via an oil return pipe, the oil return hole of each accumulator, if not appropriately sized, failed to secure an appropriate amount of return oil returned from the oil separator to the compressor and caused oil discharge from the compressor. Consequently, problems such as failures and damages due to poor lubrication arose. It was necessary, therefore, to appropriately size the oil return hole.

[0006] The present invention has been invented in view of the aforesaid circumstances, and it is therefore an object of the present invention to provide a refrigerant circuit system in which the volume of a plurality of accumulators provided in series and the size of an oil return hole are appropriately set so as to achieve both the prevention of liquid backflow and the prevention of oil discharge from a compressor caused by deteriorated oil return.

{Solution to Problem}

[0007] A refrigerant circuit system of the present invention employs the following solution to solve the foregoing problems.
More particularly, a refrigerant circuit system according to one aspect of the present invention includes: a compressor having a refrigerant suction pipe; a first accumulator; and a second accumulator, the first and the second accumulators being provided in series inside the refrigerant suction pipe of the compressor along a refrigerant circulation direction, wherein the first accumulator and the second accumulator are adapted to satisfy $V1 > V2$ where V1 is a volume of the first accumulator and V2 is a volume of the second accumulator, and wherein the first accumulator and the second accumulator are also adapted to satisfy $A1 < A2$ where A1 is an opening area of a first oil return hole provided in a refrigerant exit pipe of the first accumulator and A2 is an opening area of a second oil return hole provided in a refrigerant exit pipe of the second accumulator.

[0008] According to the refrigerant circuit system in one aspect of the present invention, the first accumulator and the second accumulator provided in series inside the refrigerant suction pipe of the compressor along the refrigerant circulation direction are adapted to satisfy $V1 > V2$ where V1 and V2 are respectively the volumes of the first accumulator and the second accumulator, while the first accumulator and the second accumulator are also adapted to satisfy $A1 < A2$ where A1 is an opening area of the first oil return hole provided in the refrigerant exit pipe of the first accumulator and A2 is an opening area of the second oil return hole provided in the refrigerant exit pipe of the second accumulator. Accordingly, even in the event that a liquid refrigerant stagnating inside the refrigerant circuit flows back in large quantities toward the compressor side at the time of startup, transitional operation and the like of the system, the first accumulator, which is structured to have a large volume V1 and to have the first oil return hole with a smaller opening area A1, can surely separate and hold the liquid refrigerant and can thereby prevent liquid backflow to the compressor. Moreover, if liquid backflow from the first accumulator should occur, the liquid refrigerant can be separated and held with the second accumulator, so that the liquid backflow to the compressor can reliably be prevented. Since the liquid backflow can basically be prevented with the first accumulator, the second oil return hole in the refrigerant exit pipe of the second accumulator, which is sized to have a larger opening area A2, incurs almost no risk of liquid backflow. Oil can reliably be returned to the compressor through the second oil return hole sized to be larger. Therefore, it becomes possible to enhance reliability in prevention of liquid backflow and to surely prevent oil discharge from the compressor caused by decreased oil return.

[0009] The above refrigerant circuit system may be structured so that a ratio A2/Al between the opening area A1 of the first oil return hole and the opening area A2 of the second oil return hole is set to at least 1.1 or more.

[0010] According to the structure, the ratio A2/A1 between the opening area A1 of the first oil return hole and the opening area A2 of the second oil return hole is set to at least 1.1 or more. Accordingly, since the first oil return hole is appropriately sized to be able to surely block liquid backflow, the liquid backflow can reliably be prevented even when the second oil return hole is sized to be 1.1 times or more larger in area ratio than the first oil return hole to assist smooth oil return. Therefore, it becomes possible to achieve both the prevention of liquid backflow and the prevention of oil discharge from the compressor.

[0011] The above refrigerant circuit system may be structured so that when an oil filled in the above compressor is an oil having compatibility with a refrigerant in an entire range of operating conditions of the compressor, the above ratio A2/A1 is set to $1.1 \leq A2/A1 \leq 2$.

[0012] According to the structure, when an oil filled in the compressor is an oil having compatibility with a refrigerant in an entire range of operating conditions of the compressor, the ratio A2/A1 is set to $1.1 \leq A2/A1 \leq 2$. Therefore, it becomes possible to achieve both the prevention of liquid backflow and the prevention of oil discharge from the compressor. In addition, it also becomes possible to ensure prevention of the liquid backflow and to secure oil return performance while avoiding a risk that the value of A2/A1 becomes too large and thereby decreases a discharge amount of the liquid refrigerant, which accumulates in the first accumulator, at the time of transitional operation, thereby resulting in overflow or gas low operation in the first accumulator. Therefore, even when an oil such as polyol ester oils (POE oils) having compatibility with the refrigerant is used as a lubricant oil of the compressor, it is possible to secure oil return performance and to implement stable operation.

[0013] The above refrigerant circuit system may be structured so that when an oil filled in the compressor is an oil incompatible with a refrigerant in an entire range or a part of operating conditions of the compressor, the above ratio A2/A1 is set to $1.1 \leq A2/A1 \leq 3$.

[0014] According to the structure, when an oil filled in the compressor is an oil incompatible with a refrigerant in an entire range or a part of operating conditions of the compressor, the ratio A2/A1 is set to $1.1 \leq A2/A1 \leq 3$. Therefore, it becomes possible to achieve both the prevention of liquid backflow and the prevention of oil discharge from the compressor. In addition, it also becomes possible to ensure prevention of the liquid backflow and to secure oil return performance while avoiding a risk that the value of A2/A1 becomes too large and thereby decreases a discharge amount of the liquid refrigerant, which accumulates in the first accumulator, at the time of transitional operation, thereby resulting in overflow or gas low operation in the first accumulator. Therefore, even when an oil such as polyalkylene glycol oils (PAG oils) incompatible with the refrigerant is used as a lubricant oil of the compressor, it is possible to secure oil return performance and to implement stable operation.

[0015] Any one of the refrigerant circuit systems described above may be structured so that an oil separator is provided in a refrigerant discharge pipe of the above compressor, and an oil return pipe which returns the oil separated in the oil separator toward the above compressor side is connected to a refrigerant pipe between the above first accumulator and the above second accumulator.

[0016] According to the structure, an oil separator is provided in a refrigerant discharge pipe of the compressor, and an oil return circuit which returns the oil separated in the oil separator toward the compressor side is connected to the refrigerant pipe between the first accumulator and the second accumulator. Accordingly, the oil separated in the oil separator and to be returned to the compressor side through the oil return circuit can smoothly be returned to the compressor side by returning the oil through the second oil return hole sized to have a larger opening area A2 in the second accumulator. Therefore, it becomes possible to surely prevent oil discharge from the compressor caused by deteriorated oil return. Further, even if any equipment which functions as a liquid reservoir is disposed in the oil return circuit, liquid backflow from the equipment can be blocked with the second accumulator, so that reliability in prevention of liquid backflow can be secured.

{Advantageous Effects of Invention}

[0017] According to the present invention, even in the event that a liquid refrigerant stagnating inside the refrigerant circuit flows back in large quantities to the compressor side at the time of startup, transitional operation and the like of the system, the first accumulator, which is structured to have a large volume V1 and to have the first oil return hole with a smaller opening area A1, can surely separate and hold the liquid refrigerant and can thereby prevent liquid backflow to the compressor. Moreover, if liquid backflow from the first accumulator should occur, the liquid refrigerant can be separated and held in the second accumulator, so that liquid backflow to the compressor can reliably be prevented. Since the liquid backflow can basically be prevented with the first accumulator, the second oil return hole in the refrigerant exit pipe of the second accumulator, even if sized to have a larger opening area A2, incurs almost no risk of liquid backflow, and oil can reliably be returned to the compressor through the larger second oil return hole. Therefore, it becomes possible to enhance reliability in prevention of liquid backflow and to surely prevent oil discharge from the compressor caused by decreased oil return.

{Brief Description of Drawings}

[0018]

{Fig. 1}
Fig. 1 is a schematic structure view showing a refrigerant circuit system according to an embodiment of the present invention.
{Fig. 2}
Fig. 2 is an enlarged view showing principal parts of the refrigerant circuit system shown in Fig. 1.

{Description of Embodiments}

[0019] Hereinbelow, one embodiment of the present invention will be described with reference to Figs. 1 and 2. Fig. 1 is a schematic structure view showing a refrigerant circuit system according to one embodiment of the present invention, and Fig. 2 is an enlarged view showing principal parts thereof.
A refrigerant circuit system 1 of the present embodiment is applied to a heat pump water heater of supercritical vapor compression type using a CO_2 refrigerant. The refrigerant circuit system 1 includes a supercritical vapor compression type heat pump (hereinafter simply referred to as heat pump) 2 and a water circulation channel 3 connected to a hot water storage tank unit which is not shown in the drawing.

[0020] The water circulation channel 3 at the side of the hot water storage tank unit includes a feed water-side channel 3A, which is connected to a water side flow channel of a radiator (refrigerant/water heat exchanger) 11 in the heat pump 2, and a hot water takeout-side channel 3B for taking out hot water prepared in the refrigerant/water heat exchanger 11. The feed water-side channel 3A is provided with a water pump 4 and a flow rate control valve 5.

[0021] The heat pump 2 is constituted from a closed cycle refrigerant circuit 21 including: a two-stage compressor (compressor) 9 having a low stage-side compressor 7 and a high stage-side compressor 8 incorporated inside a sealing housing 6; an oil separator 10 which separates a lubricant oil in refrigerant gas; a radiator (refrigerant/water heat exchanger) 11 which radiates heat of the refrigerant gas; a first electronic expansion valve (intermediate pressure decompressing means) 12 which decompresses the refrigerant to an intermediate pressure; an intermediate pressure receiver (intermediate pressure gas-liquid separation unit) 13 with a gas-liquid separation function; an internal heat exchanger (intercooler) 14 which exchanges heat between the intermediate pressure refrigerant and a low pressure refrigerant sucked into the two-stage compressor 9; supercooling coils 15A and 15B; second electronic expansion valves (main decompressing means) 16A and 16B which decompress the intermediate pressure refrigerant to a low-temperature and low-pressure gas-liquid two phase refrigerant; a plurality of evaporators (air heat exchanger) 17A and 17B which exchange heat between outdoor air sent from an unshown fan and the refrigerant; and a first accumulator 18 and a second accumulator 19 connected in series, the respective component members of the refrigerant circuit 21 being connected in this order through a refrigerant pipe 20.

[0022] In the radiator 11 of the above heat pump 2, a high-temperature and high-pressure refrigerant gas discharged from the two-stage compressor 9 is circulated to one refrigerant-side flow channel while water is circulated to the other water-side flow channel through the water circulation channel 3. Consequently, the radiator 11 functions as a refrigerant/water heat exchanger which exchanges heat between the water and the refrigerant gas. In the refrigerant/water heat exchanger 11, the water is heated by the refrigerant gas of high temperature and high pressure so that hot water is prepared.

[0023] The refrigerant circuit 21 is also connected to an oil return circuit 22. The oil return circuit 22 returns the oil separated with the oil separator 10, which is provided inside a refrigerant discharge pipe 20A extending from the two-stage compressor 9, toward a refrigerant suction pipe 20B side of the two-stage compressor 9. The oil return circuit 22 is provided with: a double pipe heat exchanger 23, which exchanges heat between a refrigerant flowing through a later-described gas injection circuit 31 and an oil; and an oil return amount adjustment mechanism 26, which is composed of a solenoid valve 24 and a parallel circuit of two capillary tubes 25A and 25B.

[0024] Further, the refrigerant circuit 21 has a hot gas bypass circuit 27 connected to between the refrigerant discharge pipe 20A and a refrigerant inlet side of the evaporators 17A and 17B. The hot gas bypass circuit 27 introduces the high-temperature and high-pressure hot gas refrigerant discharged from the two-stage compressor 9 to the evaporators 17A and 17B and defrosts the surfaces of evaporators 17A and 17B when frost is formed on the surfaces during operation at low outside air temperature. The hot gas bypass circuit 27 is provided with a solenoid valve 28 which is opened and closed when formation of frost is detected, a capillary tube 29 for adjustment of a refrigerant flow rate, check valves 30A and 30B and the like.

[0025] The refrigerant circuit 21 is also provided with a gas injection circuit 31. The gas injection circuit 31 injects an intermediate pressure refrigerant gas, which is separated with the intermediate pressure receiver (intermediate pressure gas-liquid separation unit) 13 having a gas-liquid separation function, into the sealing housing 6 of the two-stage compressor 9, which is in an intermediate pressure gas atmosphere, via the double pipe heat exchanger 23 provided in the oil return circuit 22. The gas injection circuit 31 is provided with a solenoid valve 32 and a check valve 33 so that the gas injection circuit 31 can be opened and closed where necessary.

[0026] Further in the present embodiment, as shown in Fig. 2, the first accumulator 18 and the second accumulator 19 which are placed in series inside the refrigerant suction pipe 20B of the two-stage compressor 9 are structured as shown below.

The first accumulator 18 provided upstream side in a refrigerant flow direction is constituted from a cylindrical airtight container 34 which is connected to a refrigerant inlet pipe 35 and to a refrigerant exit pipe 36 having a first oil return hole 37 provided thereon. The second accumulator 19 provided downstream side from the first accumulator 18 is constituted from a cylindrical airtight container 38 which is connected to a refrigerant inlet pipe 39 and to a refrigerant exit pipe 40 having a second oil return hole 41 provided thereon.

[0027] Thus, the constitution of the first accumulator 18 and the second accumulator 19 themselves are similar to known accumulators. However, the first accumulator 18 and the second accumulator 19 are adapted to satisfy $V1 > V2$ where V1 is a volume of the first accumulator 18 and V2 is a volume of the second accumulator 19. Therefore, the first accumulator 18 is made larger in volume than the second accumulator 19.

[0028] Moreover, the first accumulator 18 and the second accumulator 19 are also adapted to satisfy $A1 < A2$ where A1 and A2 are respectively opening areas of the first oil return hole 37 and the second oil return hole 41 provided on the refrigerant exit pipe 36 and the refrigerant exit pipe 40. Therefore, the opening area A2 of the second oil return hole 41 is larger than the opening area A1 of the first oil return hole 37. More specifically, when the first oil return hole 37 and the second oil return hole 41 are shaped into circular holes and the first oil return hole 37 has a hole size of d1 (opening area A1) and the second oil return hole 41 has a hole size of d2 (opening area A2), $d1 < d2$ is satisfied. As a consequence, a ratio A2/A1 between the opening area A1 of the first oil return hole 37 and the opening area A2 of the second oil return hole 41 is set to at least "$1.1 \leq A2/A1$".

[0029] If the value of the above ratio A2/A1 becomes too large, it raises a risk that the discharge amount of the liquid refrigerant which accumulates in the first accumulator 18 decreases at the time of transition operation and thereby causes overflow or gas low operation in the first accumulator 18. Therefore, it is preferable to set an upper limit of the above ratio A2/A1. The upper limit should preferably be set in consideration of the compatibility of the oil (lubricant oil) filled in the two-stage compressor (compressor) 9 and the refrigerant (CO_2 refrigerant). In the case of using an oil with low compatibility with the refrigerant, the oil separated inside the accumulator returns toward the two-stage compressor 9 less smoothly as compared with the oil with high compatibility. Consequently, it is preferable to set the upper limit value larger than that in the case of using oil with high compatibility.

[0030] In the present embodiment, when the oil used as the lubricant oil of the two-stage compressor (compressor) 9 is an oil having compatibility with the CO_2 refrigerant in the entire range of operating conditions of the two-stage compressor 9, such as polyol ester oils (POE oils), the ratio A2/A1 between the opening area A1 of the first oil return hole 37 and the opening area A2 of the second oil return hole 41 is set to $1.1 \leq A2/A1 \leq 2$. Moreover, when the oil for use is an oil incompatible with the CO_2 refrigerant in the entire range or a part of operating conditions of the two-stage compressor 9, such as polyalkylene glycol oils (PAG oils), the ratio A2/A1 is set to $1.1 \leq A2/A1 \leq 3$.

[0031] Moreover, the oil return circuit 22 extending from the oil separator 10 is structured to be connected to the refrigerant suction pipe 20B which connects the above first accumulator 18 and the second accumulator 19.

It is to be noted that the second accumulator 19 is a small accumulator sized to have a relatively small volume as described in the forgoing. The second accumulator 19 may be structured to be disposed integrally with an outer circumference of the sealing housing 6 of the two-stage compressor 9 via a bracket and the like.

[0032] According to the present embodiment, the following operation effects are implemented by the structure described above.

When the supercritical vapor compression type heat pump 2 with use of the CO_2 refrigerant is operated in the above refrigerant circuit system 1, a high-temperature and high-pressure refrigerant gas subjected to two-stage compression in the two-stage compressor 9 is sent to the oil separator 10, where an oil in the refrigerant is separated. The refrigerant is then introduced into the radiator (refrigerant/water heat exchanger) 11 and exchanges heat with the water which is circulated from the feed water-side channel 3A of the water circulation channel 3 to the water side flow channel. The water is heated by radiated heat from the high temperature and high pressure refrigerant gas, the temperature thereof is raised, and then returned to the hot water storage tank (not shown) through the hot water takeout-side channel 3B. The heat exchange between the refrigerant and the water is continuously performed in the radiator (refrigerant/water heat exchanger) 11 until the hot-water storage amount in the hot water storage tank reaches a specified amount. Once the hot-water storage amount reaches the specified amount, hot water storing operation is made to be ended.

[0033] The refrigerant which exchanged heat with the water and thereby cooled in the radiator 11 is decompressed by the first electronic expansion valve (intermediate pressure decompressing means) 12 and reaches the intermediate pressure receiver 13, where the refrigerant is subjected to gas-liquid separation. An intermediate pressure gas refrigerant separated in the intermediate pressure receiver 13 travels through the solenoid valve 32, the check valve 33, and the double pipe heat exchanger 23, before being injected into the intermediate pressure refrigerant gas inside the sealing housing 6 of the two-stage compressor 9 through the gas injection circuit 31. The injected intermediate pressure gas refrigerant is then sucked into the high stage-side compressor 8 and recompressed therein. An economizer effect by this gas injection makes it possible to enhance heating capability and coefficients of performance (COP) of the heat pump 2 and to expand water heating capability.

[0034] A liquid refrigerant separated in the intermediate pressure receiver 13 is supercooled in the internal heat exchanger (intercooler) 14 through heat exchange with a low pressure refrigerant gas evaporated in the evaporators 17A and 17B. The supercooled liquid refrigerant then passes the supercooling coils 15A and 15B and is decompressed by the second electronic expansion valves (main decompressing means) 16A and 16B. The decompressed liquid refrigerant becomes a gas-liquid two phase refrigerant of low temperature and low pressure and flows into the evaporators (air heat exchanger) 17A and 17B. The refrigerant which flowed into the evaporators (air heat exchanger) 17A and 17B exchanges heat with an outdoor air sent by a fan, i.e., the refrigerant absorbs heat from the outdoor air and thereby becomes evaporating gas.

[0035] The refrigerant gasified in the evaporators 17A and 17B exchanges heat with the intermediate pressure liquid refrigerant in the internal heat exchanger 14 and is used to supercool the intermediate pressure liquid refrigerant therein. Then, a liquid part (liquid refrigerant, oil) thereof is separated in the process of passing the first accumulator 18 and the second accumulator 19. As a result, only the gas refrigerant is sucked into the two-stage compressor 9 and is recompressed therein. Through repeating the subsequent similar operation, hot water is prepared. When frost is accumulated on the evaporators 17A and 17B at the time of hot water storing operation, defrosting operation can be performed by detecting the frost accumulation, opening the solenoid valve 28, and introducing the hot gas refrigerant, which is discharged from the two-stage compressor 9, from the downstream of the oil separator 10 to the evaporators 17A and 17B through the hot gas bypass circuit 27.

[0036] The oil separated from the refrigerant in the oil separator 10 passes through the oil return circuit 22 and exchanges heat with the intermediate pressure refrigerant gas in the double pipe heat exchanger 23 so as to heat the refrigerant gas. The amount of the oil is then adjusted through the oil return amount adjustment mechanism 26, and the adjusted oil is returned to the refrigerant suction pipe 20B between first accumulator 18 and the second accumulator 19. The oil once separated inside the second accumulator 19 is put into a refrigerant gas flow little by little through the second oil return hole 41 provided in the refrigerant exit pipe 40 of the second accumulator 19, so that the oil is returned to the two-stage compressor 9 side.

[0037] Herein, the first accumulator 18 and the second accumulator 19 are placed in series inside the refrigerant suction pipe 20B of the two-stage compressor 9 and are adapted to satisfy $V1 > V2$ where V1 and V2 are their volumes. Moreover, the first accumulator 18 and the second accumulator 19 are also adapted to satisfy $A1 < A2$ where A1 and A2 are opening areas of the first oil return hole 37 and the second oil return hole 41 provided on the refrigerant exit pipe 36 and the refrigerant exit pipe 40, respectively. Accordingly, even in the event that the liquid refrigerant including oil, which stagnates inside the refrigerant circuit 21, flows back in large quantities toward the two-stage compressor 9 side at the time of startup, transitional operation and the like of the refrigerant circuit system 1, the first accumulator 18, which is structured to have a large volume V1 and to have the first oil return hole 37 with a smaller opening area A1, can surely separate and hold a liquid part and can thereby block liquid backflow to the two-stage compressor 9.

[0038] As described above, the oil separated in the first accumulator 18 flows into the downstream-side second accumulator 19 in very small quantities through the first oil return hole 37. Thus, the liquid backflow from the refrigerant circuit 21 is basically prevented with the first accumulator 18, and even in the event of the liquid backflow to the downstream side from the first accumulator 18, or in the event that the refrigerant collected in the oil separator 10 or the double pipe heat exchanger 23 during shut down flows back through the oil return circuit 22, the liquid part thereof is separated and held in the second accumulator 19, so that liquid backflow to the two-stage compressor 9 can surely be blocked.

[0039] Since the liquid backflow can basically be prevented in the first accumulator 18, the second oil return hole 41 provided in the refrigerant exit pipe 40 of the second accumulator 19 side, even if sized to have a larger opening area A2, incurs almost no risk of liquid backflow. Therefore, the oil from the refrigerant circuit 21 and from the oil return circuit 22 can reliably be returned to the two-stage compressor 9 through the second oil return hole 41 sized to be larger.

Therefore, according to the present invention, it becomes possible to enhance reliability in prevention of liquid backflow and to surely prevent oil discharge from the two-stage compressor 9 caused by decreased oil return.

[0040] Moreover, in the present embodiment, the ratio A2/A1 between the opening area A1 of the first oil return hole 37 in the first accumulator 18 and the opening area A2 of the second oil return hole 41 in the second accumulator 19 are set to be at least 1.1 or more. Accordingly, since the first oil return hole 37 is appropriately sized to be able to surely block liquid backflow, the liquid backflow can reliably be prevented even when the second oil return hole 41 is sized to be 1.1 times or more larger in area ratio than the first oil return hole 37 to assist smooth oil return. Therefore, it becomes possible to achieve both the prevention of liquid backflow and the prevention of oil discharge from the two-stage compressor 9.

[0041] Particularly, not only the above area ratio A2/A1 is set to $1.1 \leq A2/A1$, but also an upper limit is set for the value of A2/A1 in order to avoid a risk that the ratio of A2/A1 becomes too large and thereby decreases a discharge amount of the liquid refrigerant, which accumulates in the first accumulator 18, at the time of transitional operation, thereby resulting in overflow or gas low operation in the first accumulator 18. When an oil having compatibility with the refrigerant (CO_2 refrigerant) in the entire range of operating conditions of the two-stage compressor 9, such as polyol ester oils (POE oils), is used as the lubricant oil of the two-stage compressor (compressor) 9, the ratio A2/A1 is set to $1.1 \leq A2/A1 \leq 2$.

[0042] Moreover, when an oil which is incompatible with the CO_2 refrigerant in the entire range or a part of operating conditions of the two-stage compressor 9, such as polyalkylene glycol oils (PAG oils), is used as the lubricant oil of the two-stage compressor, the ratio A2/A1 is set to $1.1 \leq A2/A1 \leq 3$.
Therefore, it becomes possible not only to achieve both the prevention of liquid backflow and the prevention of oil discharge from the two-stage compressor 9, but also to secure oil return performance and to implement stable operation even when either one of POE oil and PAG oil is used.

[0043] Further, the oil separator 10 is provided in the refrigerant discharge pipe 20A of the two-stage compressor 9, and the oil return circuit 22 which returns the oil separated in the oil separator 10 toward the two-stage compressor 9 side is connected to the refrigerant suction pipe 20B between the first accumulator 18 and the second accumulator 19. Accordingly, the oil separated in the oil separator 10 and to be returned to the two-stage compressor 9 side through the oil return circuit 22 can smoothly be returned to the two-stage compressor 9 side by returning the oil through the second oil return hole 41 sized to have a larger opening area A2 in the second accumulator 19.

[0044] Therefore, it becomes possible to surely prevent oil discharge from the two-stage compressor 9 caused by deteriorated oil return. Further, even if any equipment such as the double pipe heat exchanger 23 which functions as a liquid reservoir is disposed inside the oil return circuit 22, liquid backflow from such equipment can be blocked with the second accumulator 19, so that reliability in prevention of liquid backflow can be secured.

[0045] It should be understood that the present invention is not limited by the embodiment disclosed above and appropriate modifications are possible without departing from the scope and the spirit of the present invention. For example, in the foregoing embodiment, a description has been given of the case where the refrigerant circuit system 1 is applied to the supercritical vapor compression type heat pump water heater using the CO_2 refrigerant. However, it should naturally be understood that the refrigerant circuit system 1 of the present invention is widely applicable not only to the heat pump water heaters but also to various chillers, air conditioners, heat pumps and the like. As the refrigerant to be used, not only the CO_2 refrigerant, but also other refrigerants such as HFC refrigerants may be used. Chillers, air conditioners, heat pumps and the like with use of these refrigerants may also be applied in a similar manner.

[0046] Further in the aforementioned embodiment, a description has been given of the case of using the two-stage compressor 9. However, it also should naturally be understood that without being limited thereto, the present invention is applicable to chillers, air conditioners, heat pumps and the like with use of a single-stage compressor. Moreover, although a description has been given of the case where the first oil return hole 37 of the first accumulator 18 and the second oil return hole 41 of the second accumulator 19 are circular holes having the hole size of d1 and d2, respectively, they do not necessarily have to be circular holes and holes of any shape may be used as long as their opening areas are A1 and A2.

{Reference Signs List}

[0047]

1	Refrigerant circuit system
9	Two-stage compressor (compressor)
10	Oil separator
18	First accumulator
19	Second accumulator
20	Refrigerant pipe
20A	Refrigerant discharge pipe
20B	Refrigerant suction pipe
22	Oil return circuit
36	Refrigerant exit pipe
37	First oil return hole
40	Refrigerant exit pipe
41	Second oil return hole
V1	Volume of first accumulator
V2	Volume of second accumulator
d1	Hole size of first oil return hole (opening area A1)
d2	Hole size of second oil return hole (opening area A2)

Claims

1. A refrigerant circuit system, (1) **characterized in that** it comprises:

a compressor (9) having a refrigerant suction pipe (20B);
a first accumulator (18); and
a second accumulator (19),
the first and the second accumulators being provided in series inside the refrigerant suction pipe (20B) of the compressor (9) along a refrigerant circulation direction, wherein
the first accumulator (18) and the second accumulator (19) are adapted to satisfy $V1 > V2$ where V1 is a volume of the first accumulator and V2 is a volume of the second accumulator,

and wherein the first accumulator (18) and the second accumulator (19) are also adapted to satisfy A1 < A2 where A1 is an opening area of a first oil return hole (37) provided in a refrigerant exit pipe (36) of the first accumulator (18) and A2 is an opening area of a second oil return hole (41) provided in a refrigerant exit pipe (40) of the second accumulator (19).

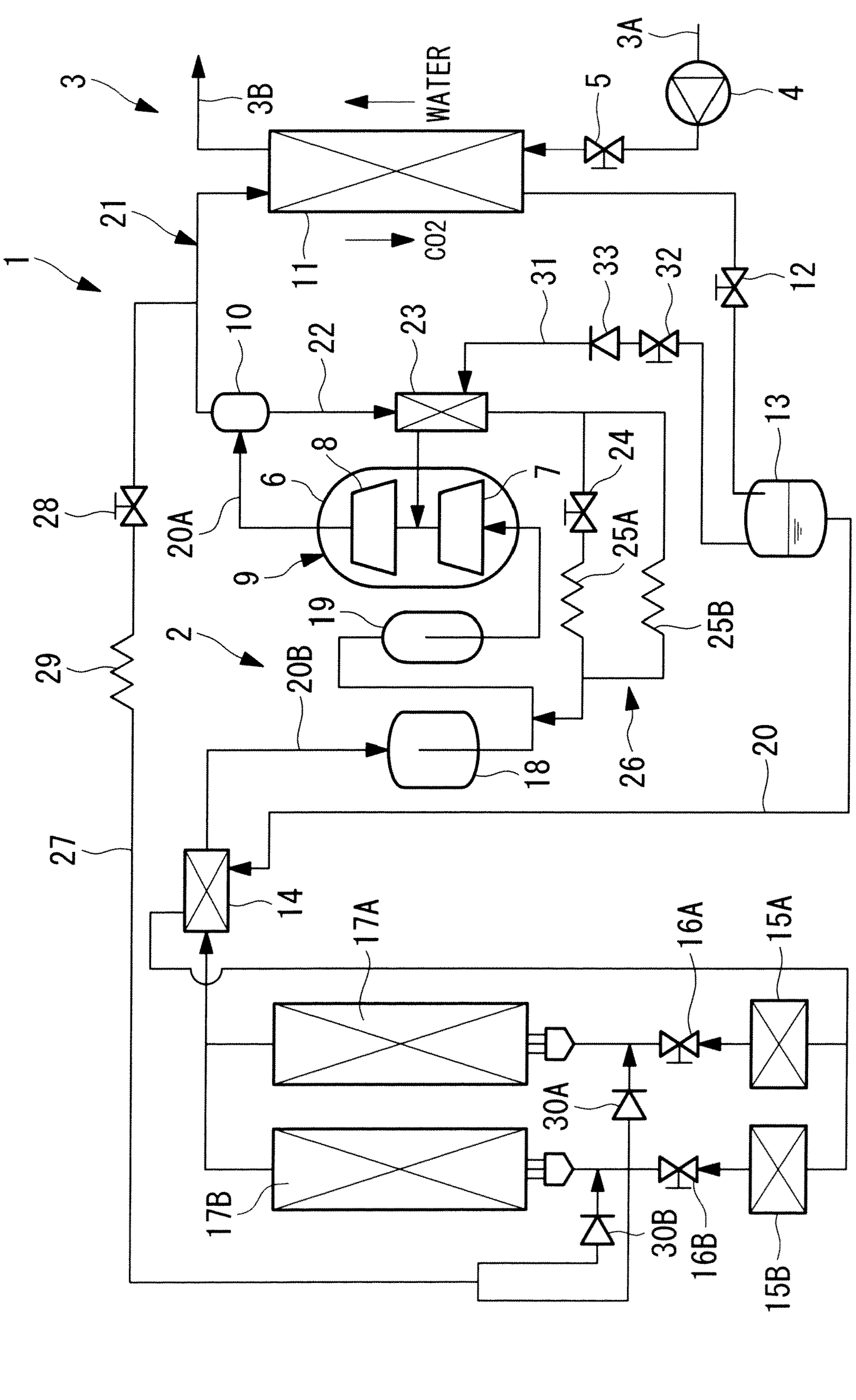
2. The refrigerant circuit system (1) according to claim 1, wherein a ratio A2/A1 between the opening area A1 of the first oil return hole (37) and the opening area A2 of the second oil return hole (41) is set to at least 1.1 or more.

3. The refrigerant circuit system (1) according to claim 2, wherein when an oil filled in the compressor (9) is an oil having compatibility with a refrigerant in an entire range of operating conditions of the compressor (9), the ratio A2/A1 is set to $1.1 \leq A2/A1 \leq 2$.

4. The refrigerant circuit system (1) according to claim 2, wherein when an oil filled in the compressor (9) is an oil incompatible with a refrigerant in an entire range or a part of operating conditions of the compressor (9), the ratio A2/A1 is set to $1.1 \leq A2/A1 \leq 3$.

5. The refrigerant circuit system (1) according to any one of claims 1 to 4, wherein an oil separator (10) is provided in a refrigerant discharge pipe (20A) of the compressor (9), and an oil return circuit (22) which returns the oil separated in the oil separator (10) toward the compressor side is connected to a refrigerant pipe (20) between the first accumulator (18) and the second accumulator (19).

FIG. 1


WATER
CO2
1
2
3
3A
3B
4
5
6
7
8
9
10
11
12
13
14
15A
15B
16A
16B
17A
17B
18
19
20
20A
20B
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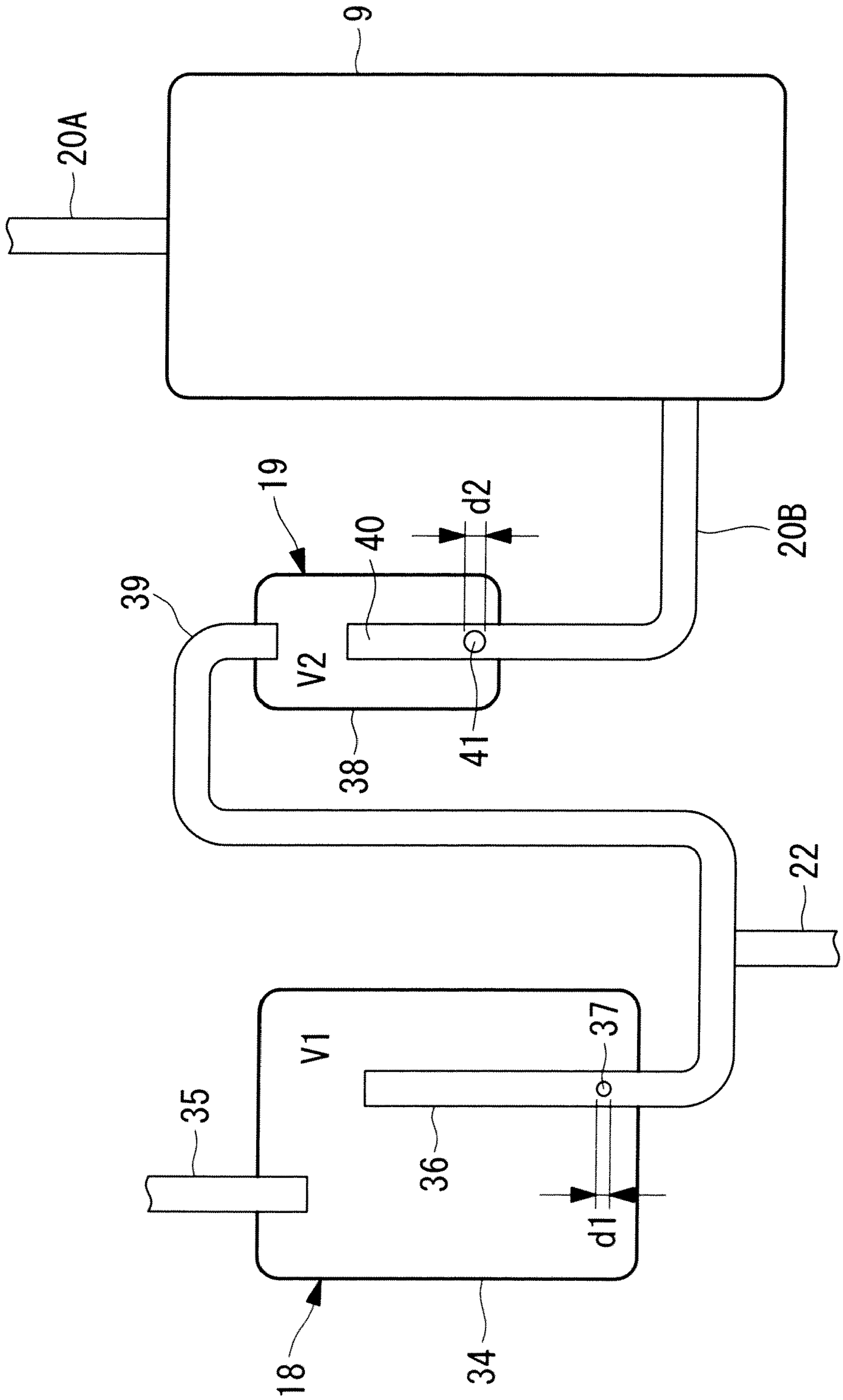
24
25A
25B
26
27
28
29
30A
30B
31
32
33

FIG. 2



REFERENCES CITED IN THE DESCRIPTION

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